SPb SUT

Impact of Node Placement on the Connectivity of Wireless Ad Hoc Networks

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Presentation plan:

- Study Objectives;
- Conception of ubiquitous sensor networks (USN) organizing;
- Definition of USN connectivity (what this means in theory and in practice);
- Test options for building networks;
- Poisson field network;
- Gaussian field network;
- Results of the USN connectivity research;
- Conclusions

Study Objectives :

•Define the area characteristics of network as a function of the **distribution of nodes** and affecting of this distribution on **the efficiency of the network** performance;

•Study of the influence of **network topology** on the **basic parameters of its functioning**;

•Studying the topology of USN properties appropriate to consider **different ways of placement of nodes** (and their parameters), defining a set of characteristics of these processes;

•Determine the dependence of the network **connectivity of the distribution of its sensor nodes**

Conception of ubiquitous sensor networks organizing:

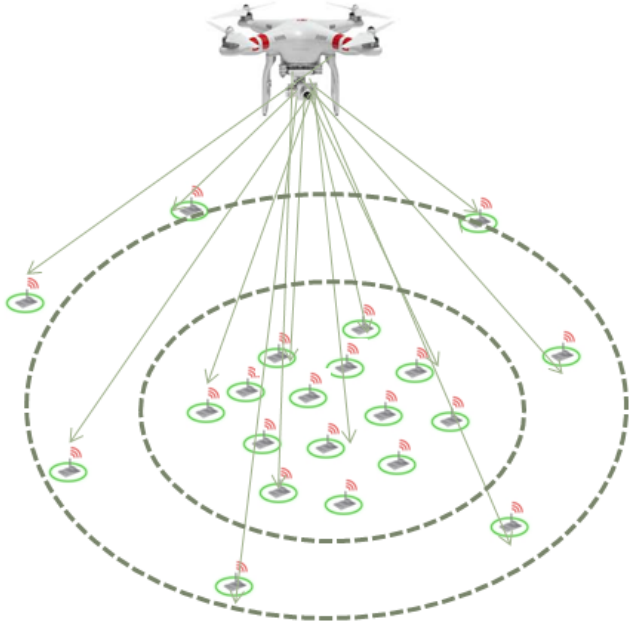
- USN may be defined by a plurality of nodes, each of which is in access zone of at least one node of the plurality, and each node has the ability to send data to a node - Gateway or any other network node.
- Network properties depend on the characteristics of the components and their relative position.
- One of the most important factors, affecting the properties of the network, is its topology, i.e., the location of the nodes relative to one another in the service area.

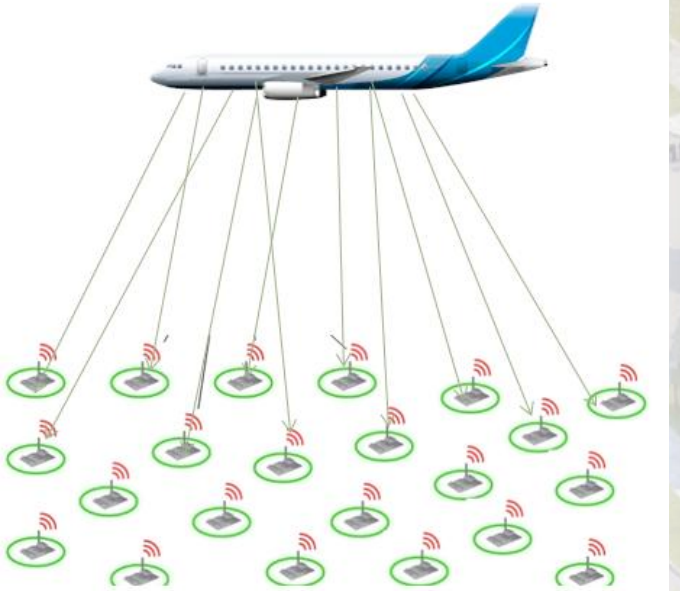
Probability of Network Connectivity (what does this mean)

- The arrangement of nodes depends on a specific purpose of the network and it gets out taking into account ensuring connectivity - stationary nodes location (in theory).
- During operation nodes can deny or change their position, for example, in the case of network with mobile nodes (on practice).
- It can be assumed that the distribution nodes randomly, therefore the links between them are also **random** (on practice).
- Make the assumption that the number of nodes is invariably and always equal to n. In this case, the network can be described as **random graph G (n, p),** where p – likelihood of a connection between nodes (in theory).
- **Erdos-Renyi model** allows describing probability of connectivity of the random graph (combination of theory and practice) .
- For large enough n, **the probability of connectivity** of the graph can be approximately estimated as $$P_{n,p}(G) = 1 - \frac{1}{n}$$

Placement of nodes (example):

Placement of nodes may be considered as **random**. In **real network** with deterministic placement of nodes, it is impossible to provide the absolute accuracy of their installation, thus it does not contradict the assumption of the random nature of their placement.

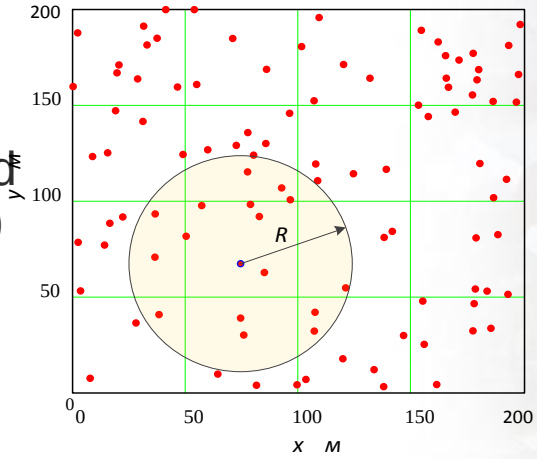




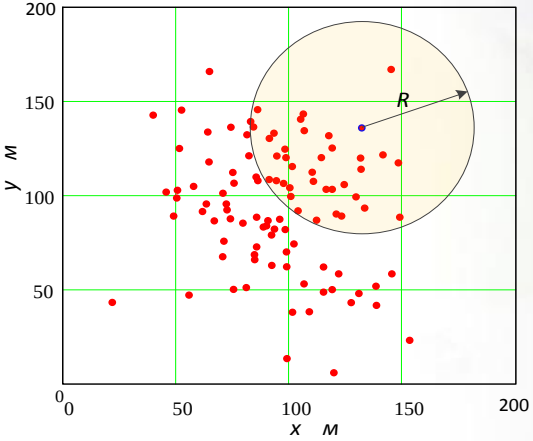
Network variants

Consider two options of network organization:

- network with nodes forming Poisson field (region bounded by a square with sides of 200 m)

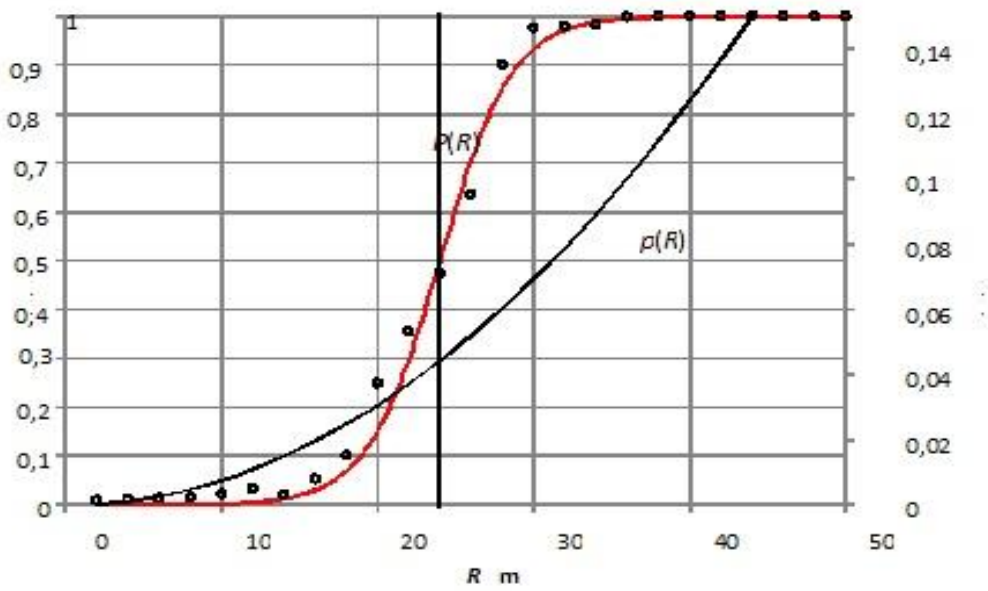


- network with nodes forming Gaussian field, i.e. network model, where coordinates of nodes are random, independent and distributed according to the two-dimensional normal distribution



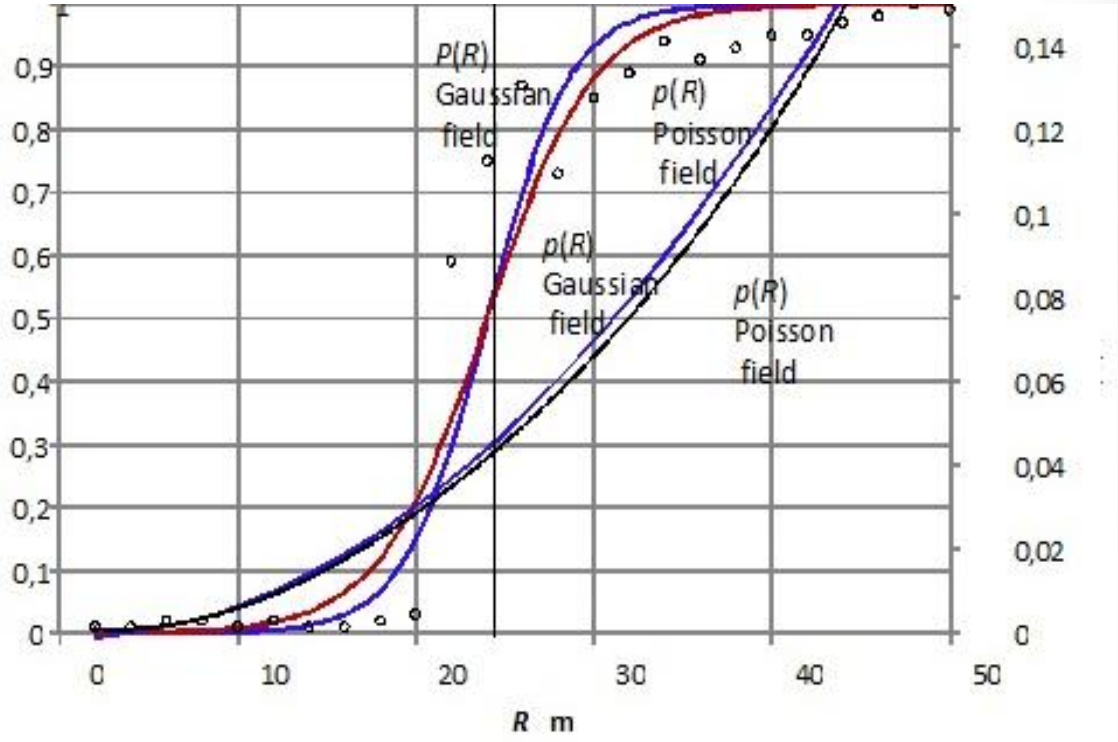
Poisson field network

Results of simulation modeling network with 100 nodes in a region bounded by a square with a side of 200 m.

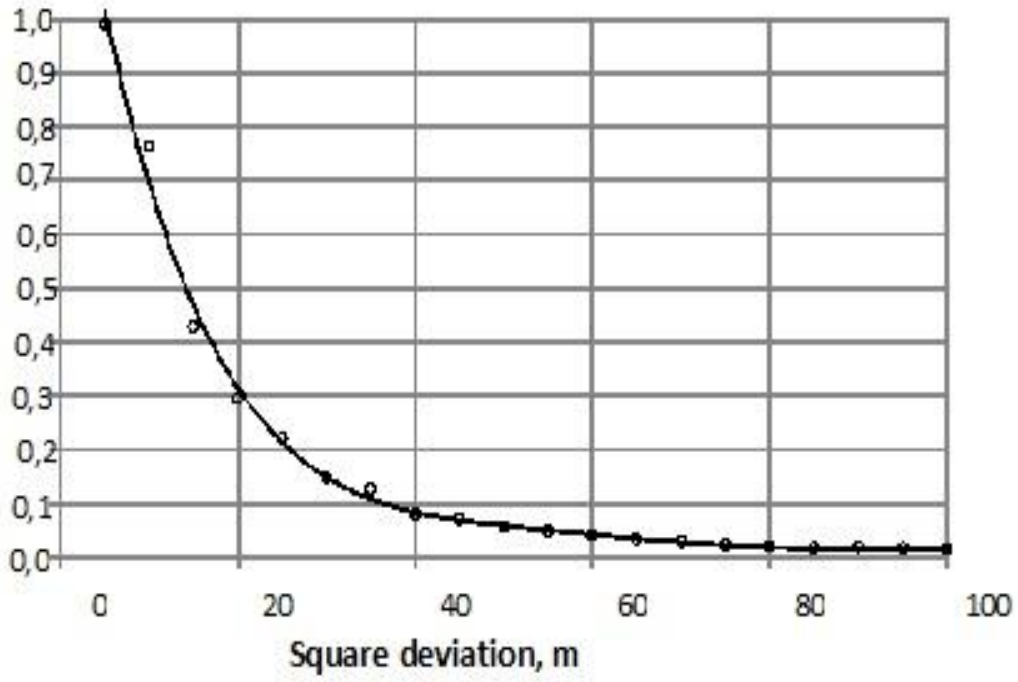


Gaussian and Poisson fields networks

Results of simulation modeling of network from 100 nodes with the radius of communication range of node - 50 m

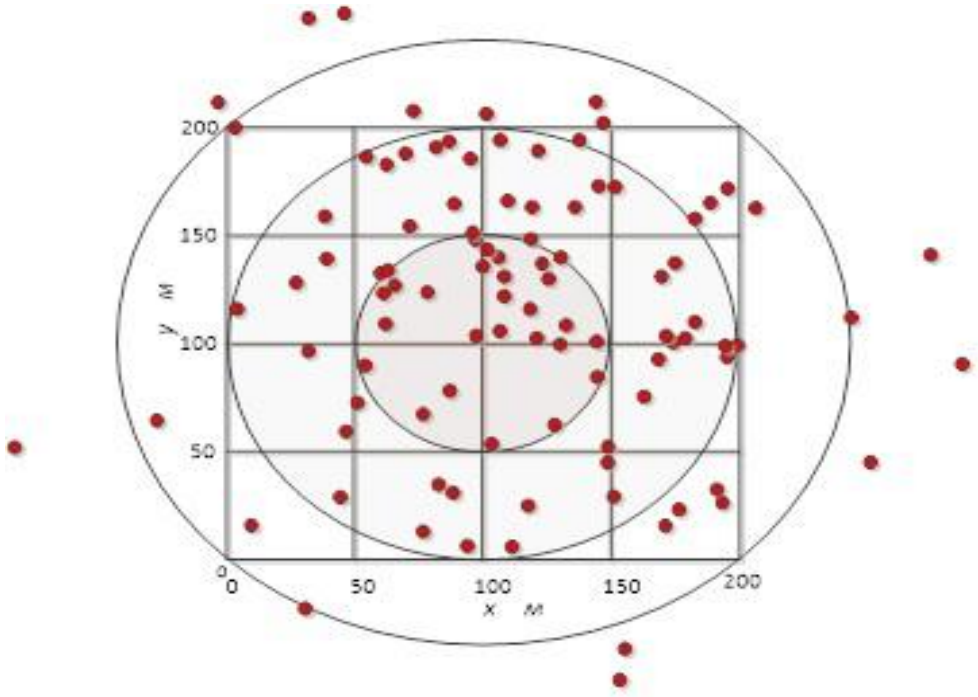


Dependence of the probability *p* of the variance for Gaussian distribution obtained by simulation

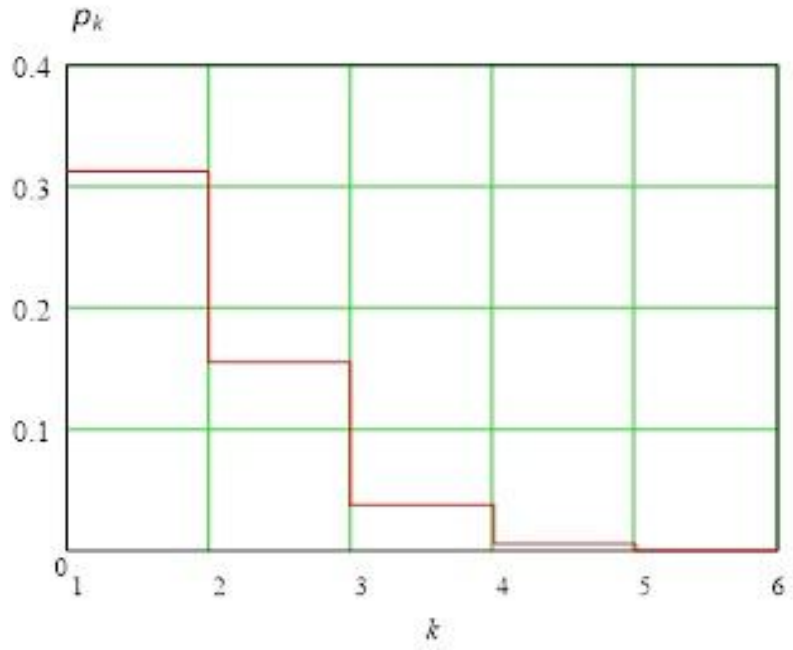


Nodes Distribution in the service area

For network with nodes distributed in compliance with normal distribution (Gaussian field) since density of nodes and probability of connectivity for them depends on their coordinates, namely on removal from a dispersion point.



Dependence of probability on the number of ring, i.e. on removal on the center of dispersion



Conclusions:

- **Random nature of nodes distribution** of wireless Ad Hoc network on territories and random nature of properties of radio channels between **nodes allow to use model of the random graph as network model.**

- By means of simulation modeling it is shown that the factor defining **connectivity** of network is **dispersion of nodes** distribution across the territory.

- Application of **Erdos-Renyi model** allows to define connectivity of network using such parameters as the number of nodes, radius of communication of node, dispersion of their distribution across the territory.

Conclusions (continuation):

- Results of modeling for Poisson and Gaussian fields showed **independence** of probability of network connectivity in general from **distribution type.**
- The results of the analysis of Gaussian distribution shows the **dependence of connectivity** in the field of network from its distance from **the center of dispersion**.
- Received an expression $p_k = \frac{\rho_{Ck} \pi R^2}{n},$

that allows to evaluate the connectivity of network in a ring of equal density proceeding from such parameters as: number of nodes, radius of communication of node, dispersion of distribution of nodes across the territory.

THANK YOU FOR ATTENTION!